Role of U.S. National Parks in Global Change Research

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INTRODUCTION

During the hot, dry summer of 1988, the greater Yellowstone area burned with an intensity probably not seen for 150 years or more. In a few weeks, an ecosystem was transformed. In 1989, Hurricane Hugo, with peak winds exceeding 330 km/hr, plowed the reefs and forests of the Virgin Islands, then reworked the shoreline and flattened the evergreen forests of the South Carolina coast. The effects of these disturbances will be studied for decades as the ecosystems establish a new dynamic. We cannot say whether global warming was a factor, but we do know that these are the kinds of phenomena to be expected more frequently under global change.

In the next century, natural ecosystems may begin to experience unprecedented changes in the magnitude, seasonality, frequency, geographic extent, and duration of climatic extremes. The effects of changes in wildfire, drought, severe storms, unusual precipitation patterns, and extremes of heat and cold would be interactive and cumulative with the effects of CO_2 fertilization, sea level rise, enhanced ultraviolet radiation (related to stratospheric ozone depletion), and other factors in global change. Species would be affected differently according to their sensitivity to the particular combinations of stresses. Under such conditions, ecological communities that took millennia to develop could disassociate rapidly. To address this situation, ag-

gressive management on a scale unimaginable today would be required to enable the continuing evolution of many species in the wild. Whether such management of natural ecosystems will even be possible is highly problematical (U.S. National Academy of Sciences 1991). However, managers must begin to address the consequences of global change predictions that currently exist (Joyce, Fosberg, and Comanor 1990).

In recent decades, we have learned much about the practice of ecosystem management. We routinely prescribe burns to restore the natural role of fire in fire-dependent ecosystems, such as those at Everglades and Sequoia National Parks. We are successfully restoring wetlands and endangered species, especially mammals and vascular plants, and using integrated management approaches to control exotic species. The goal of U.S. national parks and many natural areas is to restore natural processes disrupted by human influences, either directly or indirectly. The implicit assumption is that once we repair the damage, we can reduce or eliminate the need for active management to sustain the natural processes and species populations.

Rapid directional changes in atmospheric composition and global climate would have profound implications for national park managers. Protected areas would become unsuitable for many species they now support, and newly suitable for species now found elsewhere. For many species, migration across natural barriers or landscapes fragmented by human uses would be especially problematical. For some, migration to or from protected area habitats without management assistance would be impossible. Under such conditions, cooperative management of large biogeographical areas offers the best chance for maximizing biodiversity and minimizing the biological impoverishment of the protected areas (Parsons 1991).

Cooperative management of biogeographical areas is a desirable management goal. However, it is difficult to achieve in practice. Managing agencies and organizations often have had vastly different policies and public constituencies. Consensus on management goals is often difficult to achieve. In this environment, cooperation in developing and sharing scientific information now can pave the way for stakeholders to work together later on the more difficult task of responding to complex regional management issues. Unfortunately, most biogeographical areas do not yet have a cooperative framework for pooling intellectual, technical, and financial resources to develop and share information.

A biogeographical area may be defined as a geographic area within a terrestrial biogeographical province (*sensu* Udvardy 1975) or coastal region (*sensu* Ray 1975) that is distinguishable on the basis of some combination of physiography, climate, vegetation, characteristic species, natural processes, human populations, and characteristic resource uses. It is essentially a biogeocultural region (*sensu* U.S. MAB 1989) containing one or more protected areas that provides an optimal scale for managing most components of biological diversity, and for practical actions to address many human influences on ecosystem processes. The scale is suitable for integrating the natural and social sciences in understanding the complex factors in ecosystem sustainability, and for demonstrating participatory democratic approaches in using scientific information effectively for solving ecosystem management problems.

THE PROMISING ROLE OF BIOSPHERE RESERVES

The scientific and educational value of the world's outstanding conservation areas may ultimately be their finest legacy to human society. Biosphere reserves uniquely enable these areas to contribute relevant scientific information for sustaining ecosystems at scales ranging from local to global (Dyer and Holland 1991). A biosphere reserve offers the potential of linking park-based research with other research in the biogeographical area, the larger biogeographical province, other biogeographical provinces within the same biome, and among the biomes constituting the global earth system. These linkages strengthen the role of protected areas to society as bellwethers of ecosystem change and benchmarks for assessing the effects of human activities. By expanding the constituency for this role, biosphere reserves encourage commitment to long-term research programs.

Biosphere reserves help their stakeholders achieve a balance among ecosystem uses in a way that sustains the natural ecosystem processes and the biological resources of their biogeographical area. Many countries have organized multi-sector associations of government, nongovernmental entities, and local people around the unifying biosphere reserve concept. Flexibly adapted to the conditions of the biogeographical area, the new organizations provide needed permanent forums for stakeholders in ecosystem sustainability to discuss the resource issues that concern them on a regular basis, and learn the art of cooperation. They are building the broad public constituency for the research, education, and demonstration projects that make solutions possible. Ultimately, these cooperative organizations may prove to be the biosphere reserves' greatest contribution. As these emerging organizations succeed in pooling intellectual, technical, and financial resources locally, opportunities for links with issues and activities at wider scales will inevitably emerge. Some biosphere reserves are already contributing useful data to improve general circulation models and predictions of the regional effects of global change. However, their practical management benefits will come in the future as biosphere reserves use the models to formulate and demonstrate adaptive strategies for sustaining ecosystems and biological diversity under conditions of global change.

THE USNPS'S GLOBAL CHANGE PROGRAM: A BIOGEOGRAPHICAL AREA APPROACH

The U.S. National Park Service (USNPS) Global Change Program seeks to provide predictive and holistic understanding of the effects of global change on species populations, ecological communities, watershed processes, and landscape dynamics through the coordinated use of parks as benchmark research sites within larger biogeographical areas. In each biogeographical area, cooperation with other agencies and organizations involved in global change research is an important program goal. To optimize the possibilities for networking inherent in the biosphere reserve model, each biogeographical area includes at least one existing or potential USNPS unit of the international network of biosphere reserves. This core research area is the focus of most of the USNPS research. However, in some biogeographical areas, one or more contributing USNPS units are also involved. These support the biogeographical area program by providing complementary resources, research capabilities, and data sets. They also provide the opportunity to complete the research design, corroborate results, test research hypotheses, and apply pre-

dictive modeling to the biogeographical area and the larger biogeographic province.

The USNPS Global Change Program also includes thematic initiatives that complement the biogeographical area programs. These primarily involve coastal and marine systems. They are multi-regional, and focus on specific research topics. An initiative to understand potential global change effects on coastal barrier dynamics is underway, and another on the structure and physiology of coral reefs is planned to begin in 1993.

Each biogeographical area has a designated research coordinator and funding for operational support of a long-term research program. Most coordinators are located at regional universities, which provide access to interdisciplinary research capabilities. To date, we have initiated global change research in six temperate-forest biogeographical areas: the Olympic Peninsula, the central and southern Sierras, the Glacier National Park area, the Colorado Rockies, the Ozark highlands, and the western Great Lakes. During the next year, we expect to add biogeographical areas in the central grasslands, South Florida (Everglades), Sonoran Desert, and the Gulf Coast. At full development, the program is planned to include 20 biogeographical areas representing most of the biomes in the United States (Figure 1). Research will be initiated as funding and cooperative research opportunities develop.

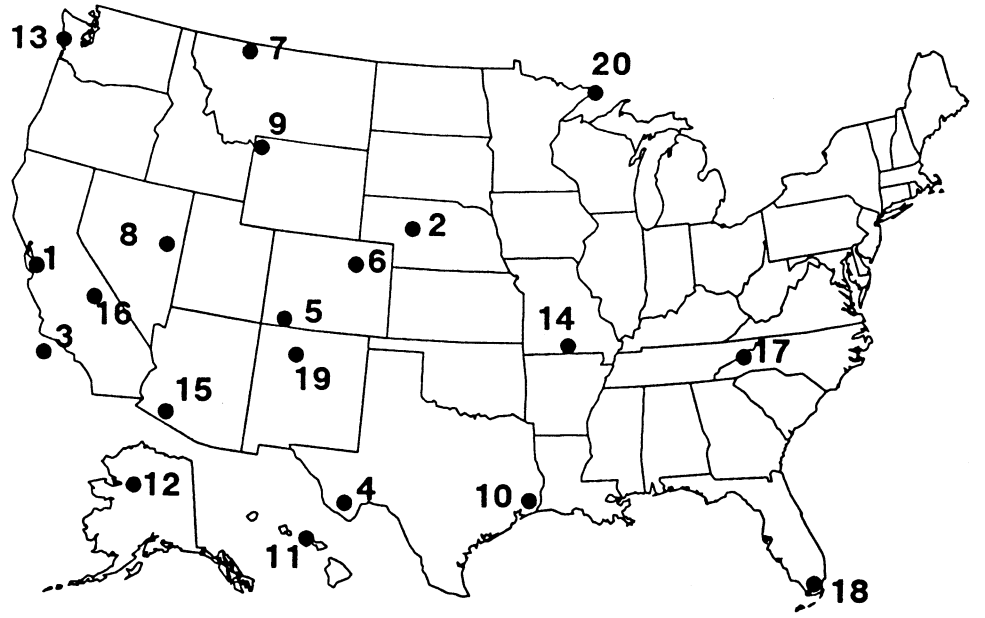
Ongoing research varies among the biogeographical areas, reflecting (among other things) the historical research strengths of the participating parks, the park and university expertise, the sensitivity of the resources to global change, and the results of a rigorous peer-review and competitive selection process. Ongoing projects support four of the seven science elements in the interagency U.S. Global Change Research Program (Committee on Earth and Environmental Sciences 1991): earth system history, ecological systems and dynamics, biogeochemical dynamics, and climate and hydrologic systems. The initial projects emphasize particular areas of disciplinary study (Table 1). However, the long-term objective is to link these studies with future USNPS and outside research at many scales to develop interdisciplinary assessments and, eventually, adaptive response strategies for the larger areas.

Table 1. Committee on Earth and Environmental Sciences research elements by USNPS biogeographical area, 1991

	Ecological Systems & Dynamics	*Earth System History*	*Biogeo-chemical Dynamics*	*Climate & Hydrologic Systems*
Central Grasslands	•			•
Colorado Rockies	•		•	•
Glacier NP area	•		•	
Ozark highlands	•	•	•	
Olympic Peninsula		•		•
Sonaran Desert*	•	•		
South Florida*	•	•		•
South/Central Sierra	•	•		
Western Great Lakes		•		

*** Initiation proposed for 1992**

Figure 1. USNPS Global Change Research Program biogeographical areas

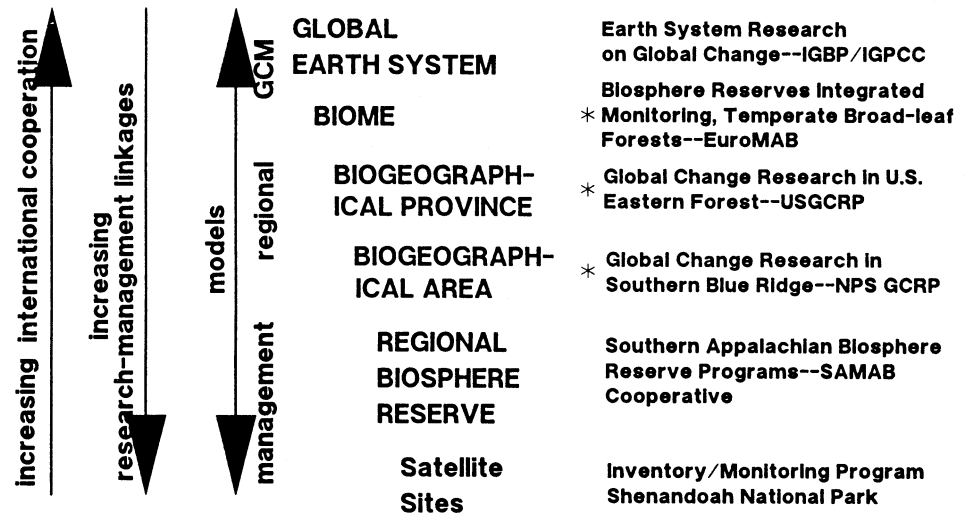


1. *Central California Coast*
2. *Central Grasslands*
3. *Channel Islands*
4. *Chihuahuan Desert*
5. *Colorado Plateau*
6. *Colorado Rockies*
7. *Glacier National Park area*
8. *Great Basin*
9. *Greater Yellowstone*
10. *Gulf Coastal Plain*
11. *Hawaiian Islands*
12. *Northwest Alaska*
13. *Olympic Peninsula*
14. *Ozark highlands*
15. *Sonoran Desert*
16. *Southern/Central Sierra Nevada*
17. *Southern Blue Ridge*
18. *South Florida*
19. *Upper Rio Grande*
20. *Western Great Lakes*

Figure 2 shows opportunities for global change networking, using the Great Smoky Mountains National Park as an example. The park has a long history of site-level monitoring and research relevant to global change. It participates in the Southern Appalachian Man and the Biosphere Cooperative, an organization of eight federal and state agencies for cooperating on regional resource issues. The Cooperative's activities focus largely on the Southern Appalachian Biosphere Reserve, which includes Great Smoky Mountains, two long-term ecological research areas, three additional areas nominated for inclusion, and a large surrounding "area of cooperation." A nonprofit Southern Appalachian Man and the Biosphere Foundation facilitates private-sector participa-

tion. The park is also part of a large biogeographical area which is being considered for inclusion in the USNPS Global Change Program. The biogeographical area includes Shenandoah National Park, a satellite research site recently selected as a prototype for biological inventory and monitoring to help address many issues, including global change. At wider spatial scales, the U.S. Global Change Research Program facilitates regional and national research links. International biome-based links for global change research will benefit from efforts of European and North American Man and the Biosphere programs to strengthen cooperation among their biosphere reserves, and the international activities of the Intergovernmental Panel on Climate Change (IPCC 1990, 1991) and Scientific Committee on Problems of the Environment (SCOPE 1990).

Figure 2. Potential program-scale links for temperate broad-leaved forests



A PRELIMINARY PROGRAM ASSESSMENT

Integrating national parks into the complexities and many scales of global change research will take time. However, the USNPS Global Change Program has taken important steps that have broad implications for strengthening the role and credibility of research in national parks, and the role of parks in addressing issues of ecosystem sustainability. We provide a brief assessment of the program's strengths and weaknesses at this early implementation stage to assist others contemplating a similar research effort.

Program development relied on an open competition of proposals based on a conceptual research plan for the biogeographical area. The process tapped the creativity and experience of agency and outside researchers. It resulted in the selection of parks in western mountain areas with a strong history of research. On the other hand, plans and proposals reflected the limited familiarity and experience of park researchers with global change issues. Many were not well-focused on the research issues and priorities

of the USNPS Global Change Program. The initial selections were not biogeographically balanced.

This program has the most extensive outside peer review of any program USNPS has undertaken. The review, which occurs at both concept plan and proposal stages, has helped establish credibility both inside and outside the agency. Yet this critical evaluation resulted in rejection of many proposals that were desirable to achieve in an integrated, interdisciplinary program but did not meet the scientific review criteria.

This is the first link of U.S. national parks to a highly structured domestic and international research program to address a global issue. Although the program was designed to contribute significantly to this effort, a more modest than expected funding level has delayed the initiation of research in many biogeographical areas.

A committee of USNPS scientists and managers, selected on the basis of professional expertise, coordinates the national program. This is the agency's first use of such a mechanism, which has been particularly successful.

This is also USNPS's first nationally directed research program to have a full-time data administrator. This underscores commitment to contribute well-document, high-quality data sets to the national effort.

The program has created a field organization to facilitate research on a biogeographical area rather than administrative-area basis. While the approach has enhanced possibilities for ecologically based cooperation, coordinators supported under the national program have sometimes had difficulty coordinating activities across administrative areas having different capabilities, interests, and local priorities.

We are the only U.S. federal land-managing agency to adopt the cooperative biogeographical area approach for global change research. However, cooperation has been easier to conceptualize than to carry out because agency development of on-site research has necessarily taken priority over inter-site links in the first program stage.

CONCLUSIONS

The USNPS's Global Change Program's success has been reflected in the quality of the research proposals, the enthusiastic support of field units, and in the intense competition for the field coordinator positions. However, achieving the larger goal of an integrated, multi-agency, cooperative biogeographical area research effort would benefit from having biosphere reserve research links with other agencies and organizations in place before preparing global change research plans. These associations could help coordinate research objectives among agencies in the biogeographical area and link them to Global Change Program milestones. Proposals could be considered in "sets" rather than individually, brought up to standards, and integrated before the biogeographical area is funded and the research begins. If necessary, the type of research desired in each biogeographical area could be cooperatively specified at the start, and proposals solicited by the participating entities accordingly.

Our initial experience indicates the utility of organizing global change research on a biogeographical area basis, with emphasis on the use of biosphere reserves. These areas may provide the most suitable framework for communication among the many sectors with a stake in achieving ecosystem sustainability in ways that maintain biological diversity under changing environmental conditions.

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